

# *The ATLAS ZDC Project 11/09*

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*Burton Budick\**

*NYU*

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*Columbia University*

*Valeri Pozdnyakov, Yuri Vertogradova*

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State University of New York at Stony Brook*

*\*=Diffractive Physics (Heavy Ion and p-p)*

# Outline

- *Applications*
  - HI*
  - Luminosity*

- *Timeline*

- *Cost Rollup*

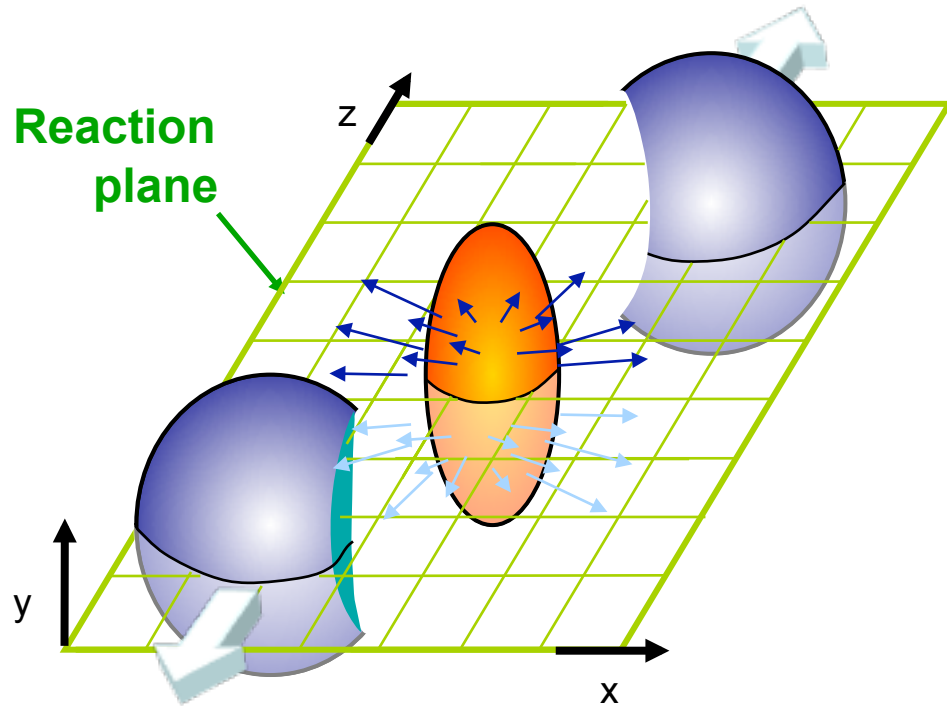
- *Little Loose ends*

- *Bigger Loose ends*

- *Group Plans*

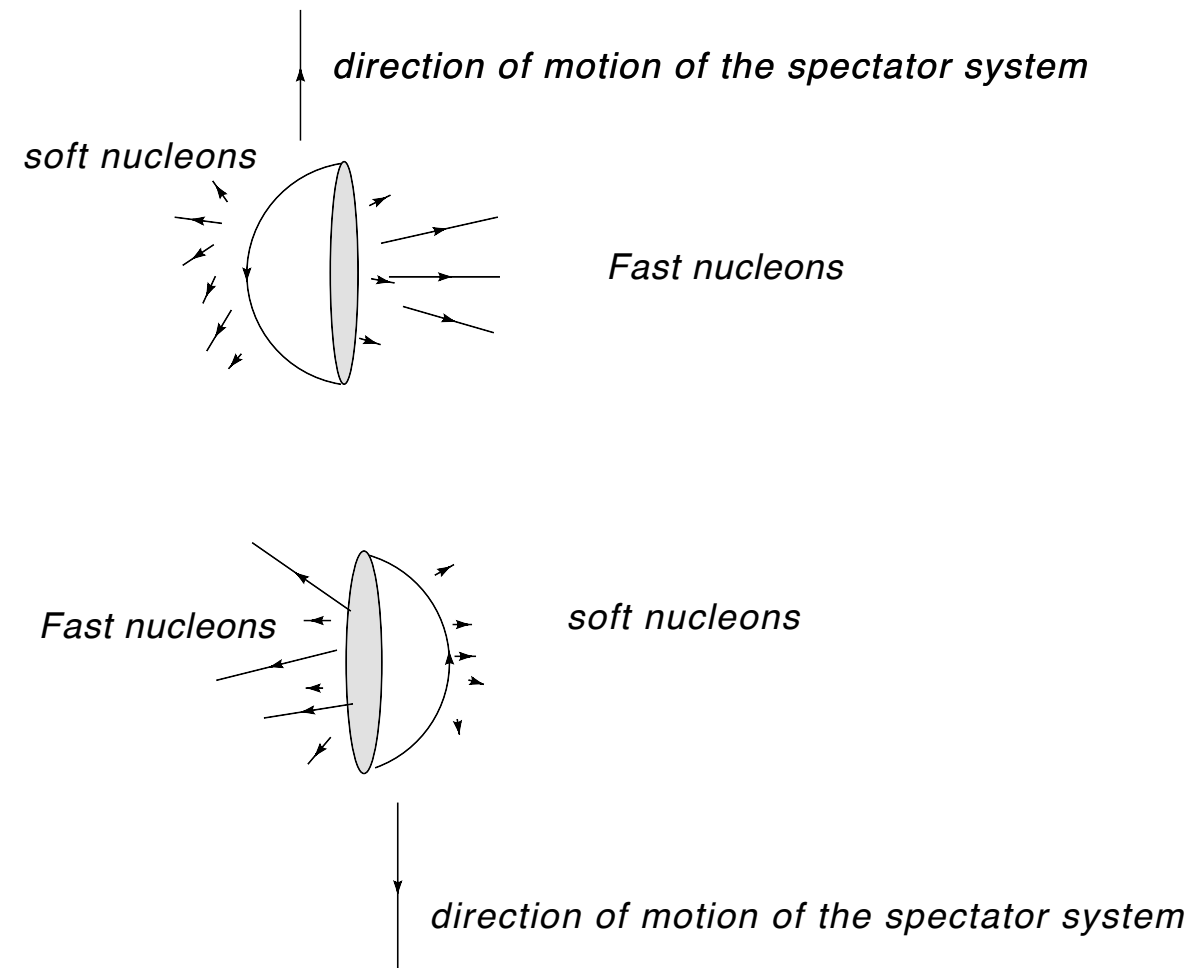
# Heavy Ions

Masashi Kaneta/Shinichi Esumi



- ZDC is the standard for event characterization.
- ZDC multiplicity  $\propto$  impact parameter
- Kaneta and Esumi showed it is also best for reaction plane determination.

Mark Strikman, SNW



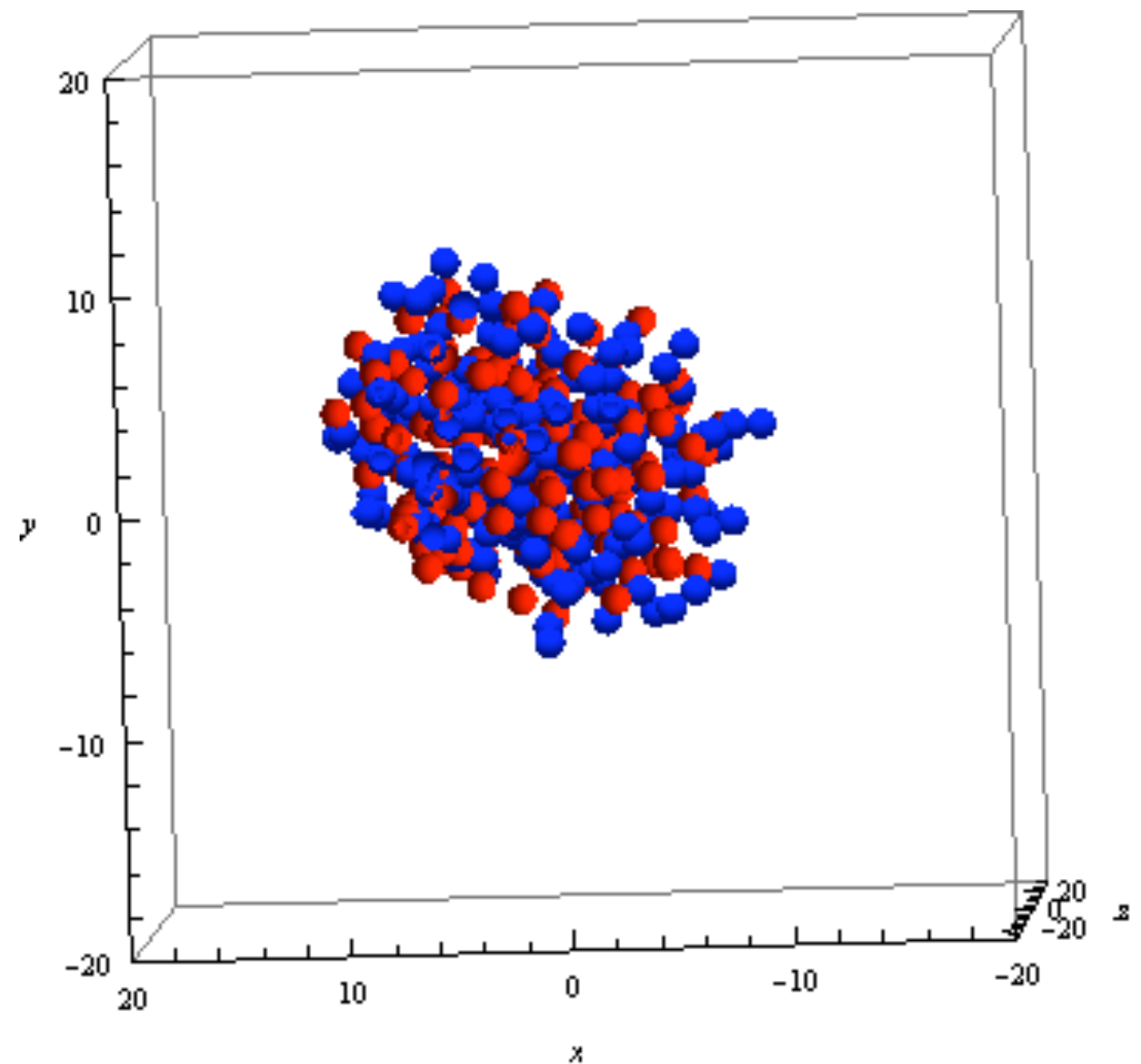
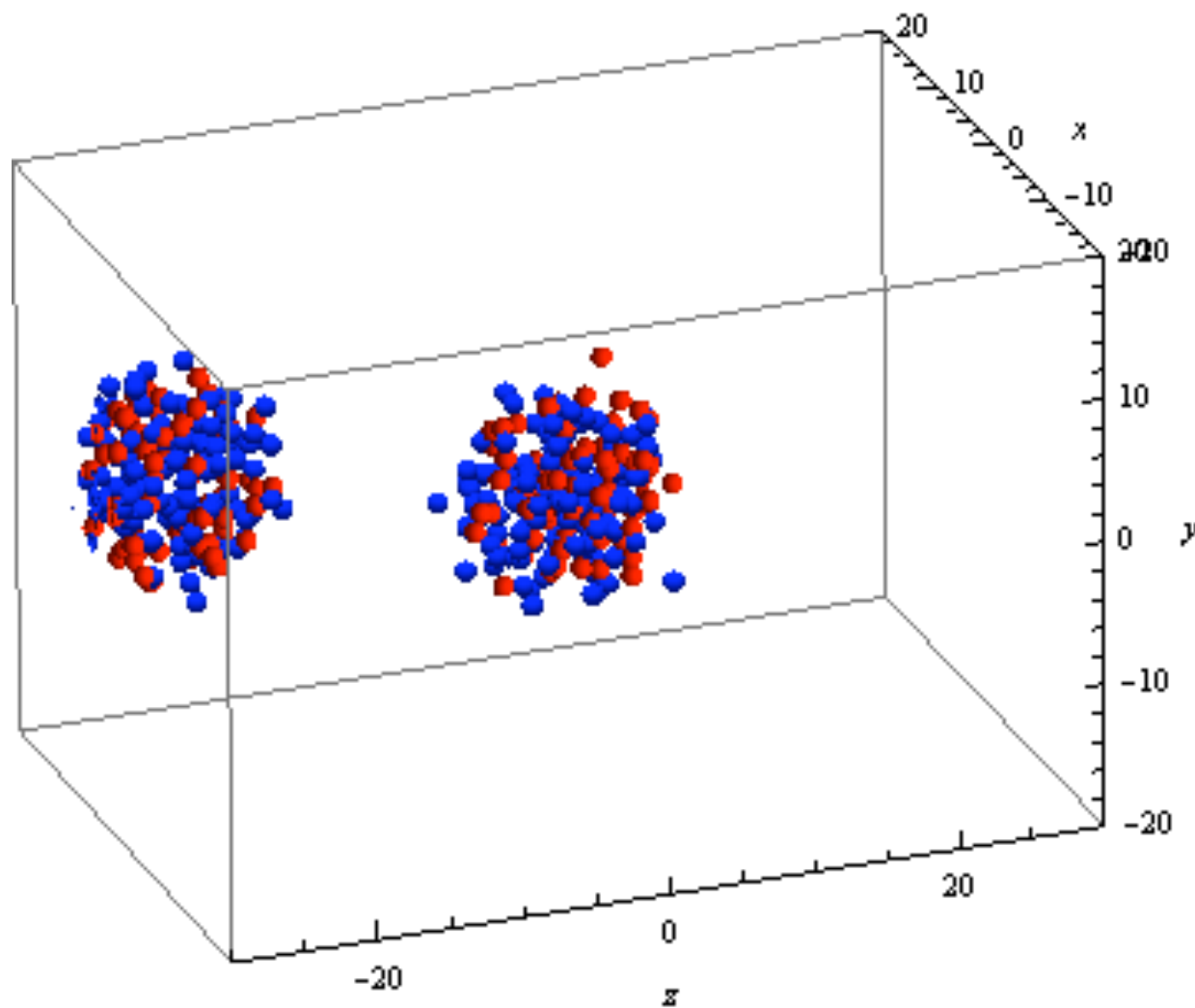
Bad tools in HI community (HIJING very bad, uRQMD less bad)

Nov. 24th

ZDC-BNL Construction closeout

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Csorgo, Strikman & SNW +student @BNL

- Realistic initial coordinate configuration
- nucleon internal momentum distribution
- short range correlations
- soft evaporation neutrons
- **HIJING has none of these**
- PHENIX passed up low energy run due to this error
- this has also been a problem in other fields (Shaevitz)

[\[0910.3205\] Beam Fragmentation in Heavy Ion Collisions and its ...](#)

Title: Beam **Fragmentation** in Heavy Ion Collisions and its implication for RHIC triggers at low s. Authors: Sebastian White, Mark Strikman ...

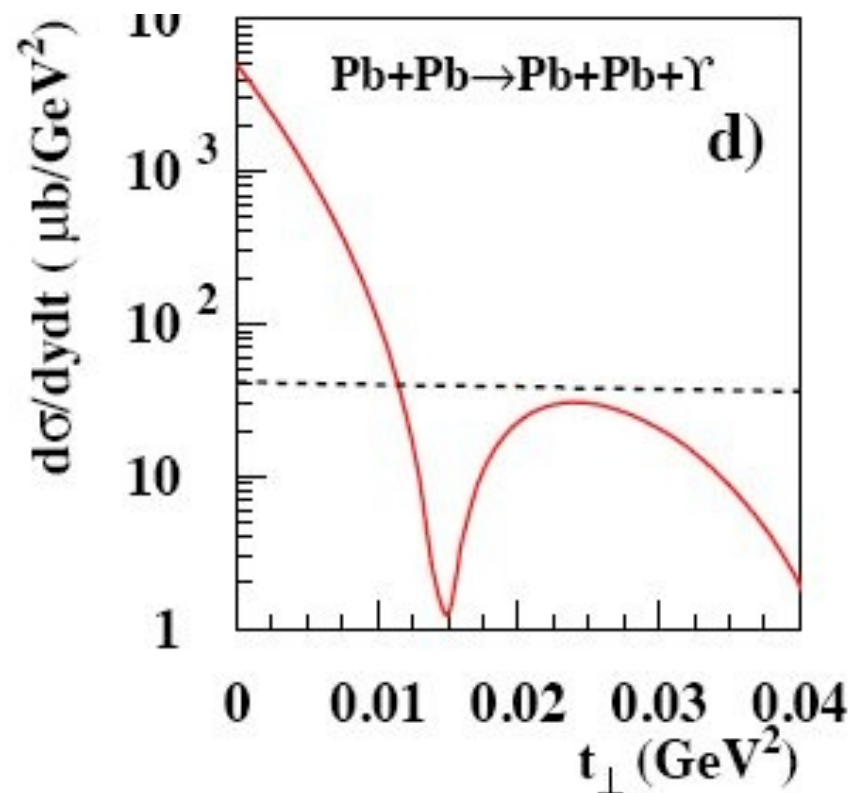
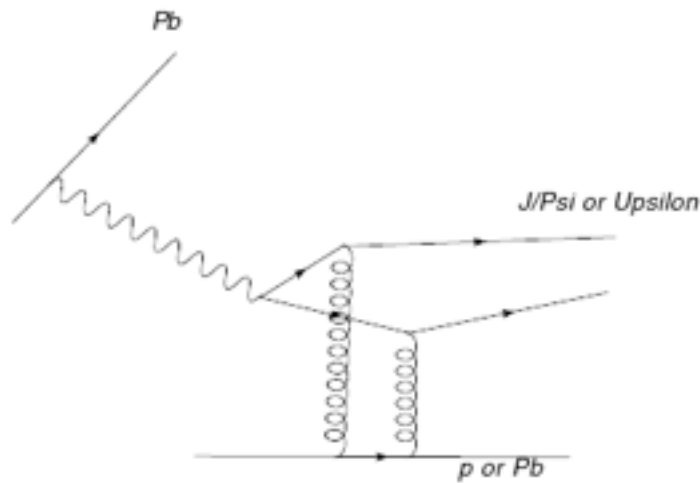
[arxiv.org/abs/0910.3205](http://arxiv.org/abs/0910.3205) - [Cached](#)

by S White - 2009 - [Related articles](#) - [All 4 versions](#)

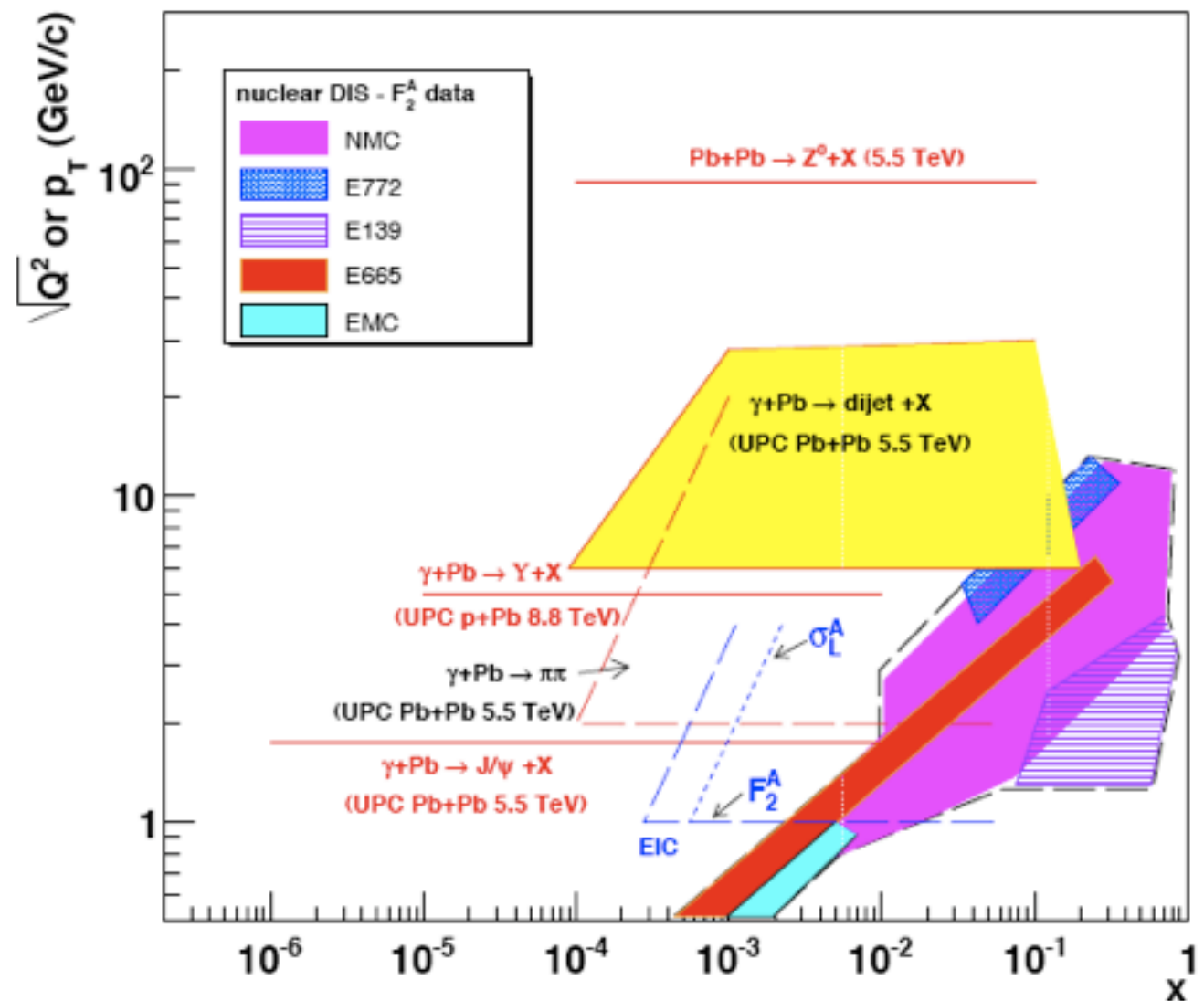
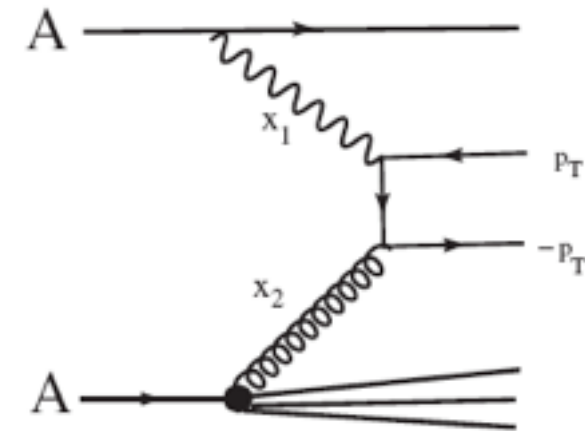
- “gluon distribution in proton or nucleus”  
(Strikman, SNW + PHENIX data('04)+'07)

- $1 J/\psi \text{ min}^{-1}$  (RHIC),  $10 \text{ sec}^{-1}$  (ATLAS)

$$\frac{d\sigma}{dt}(J/\psi - \text{Nucleus}) \longrightarrow \text{“QCD Rutherford scattering”}$$



- “the structure of Protons and Nuclei”  
(Strikman, Vogt, SNW)



# Luminosity

- ATLAS (and other LHC) are very serious about it
- ISR(  $h_{\text{eff}}$ -only, DC also CERN-ROME/Pisa-SB) famous  $\sim 1\text{-}2\%$
- $Sp\bar{p}S$ ok
- Tevatron: 10% difference never technically resolved, D0 RP's never got  $\sigma_{\text{tot}}$  data neither CDF or E710 got  $\rho$  (ATLAS goal)
- RHIC: Au-Au and d-Au- $\rightarrow$  5% physics based luminosity, p-p- $\rightarrow$  no  $\sigma_{\text{tot}}$  or  $\sigma_{\text{el}}$  result, accelerator based halted after 1 run (systematics problem)
- many useful interactions with RHIC (Wolfram, Roser, Peggs, Cameron) on this problem

# Luminosity(ATLAS strategy)

1) “alfa”

$$\begin{aligned}\frac{dN}{dt} &= L\pi|F_C + F_N|^2 \\ &= L \left( \frac{4\pi\alpha^2(\hbar c)^2}{|t|^2} - \frac{\alpha\rho\sigma_{tot}e^{-B|t|/2}}{|t|} + \frac{\sigma_{tot}^2(1+\rho^2)e^{-B|t|}}{16\pi(\hbar c)^2} \right)\end{aligned}$$

2) Luminosity Monitoring

LUCID: LHCC (CERN/LHCC/2004-010)

ZDC: AB-Note-2005-030 BDI Schmickler and SNW

today-> +MBTS+BCM+Vertex+FCAL+....

3) Beam Separation Scans (ZDC is fully integrated including LHC data exchange). Systematics much discussed. BNL could help.

4) Many stages to this strategy. My feeling is BSS could make or break it. Alfa very good people but impossible.

5) Good cooperation between ATLAS<-> CMS on ZDC


# Project timeline

w. Bill Turner on USLARP/TAN	1999
ATLAS-HI LOI to DOE	3/02
LHCC closed wkshop on Heavy Ions SNW (RHIC accel and future dets) Helio (ATLAS phys. and ZDC)	6/02
<u>ATLAS-ZDC design(Alexei), pro/engineer files</u> <u>(jason) integrated with TAN and BRAN</u>	3/04
Full GEANT3 simulation->20%(E) and 100 ps	3/04
ATLAS submits Heavy Ion LOI to LHCC	/04
S. Aronson announces BNL funding of ZDC at CMS level	/04

November 24

ZDC/BNL construction closeout

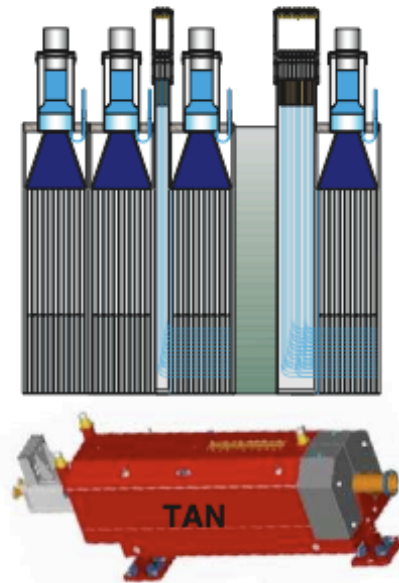
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S.A and SNW meeting with Peter and Fabiola	6/04
Mike Zeller group joins ZDC	12/05
IHEP leaves ZDC	2/06
New design: Quartz/Quartz optical fiber replaced with unclad Quartz rods,increased light allows x,y measurement from “shashlik”	2/06
BLIP radiation test (->5Grad limit), CERN north area beam test (data on light yield)	9/06
ZDC LOI submitted to the LHCC by ATLAS	1/07
L1Calo solution adopted for DAQ	7/07
ATLAS funds 175k ChF for RP robotics	/08
	
ZDC Installation week+Slice week (no BNL)	5/09

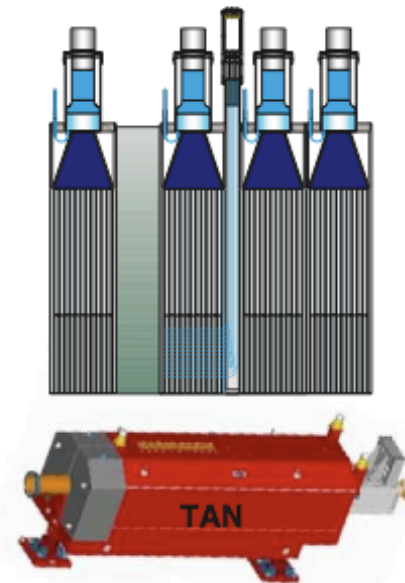


# Volodja design

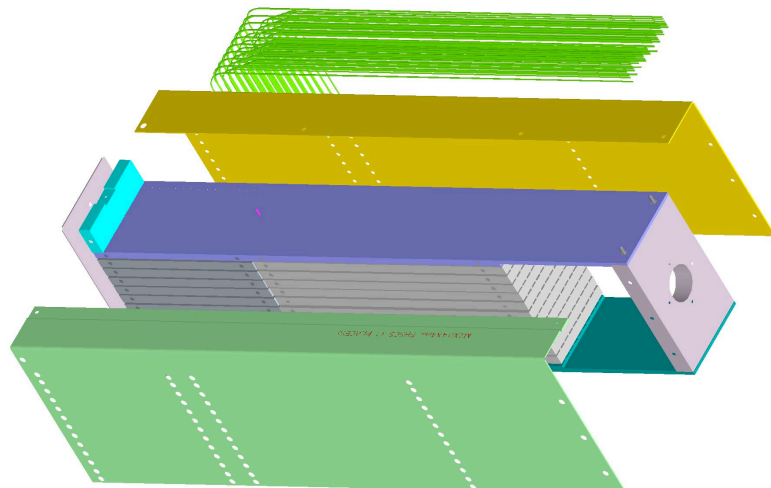
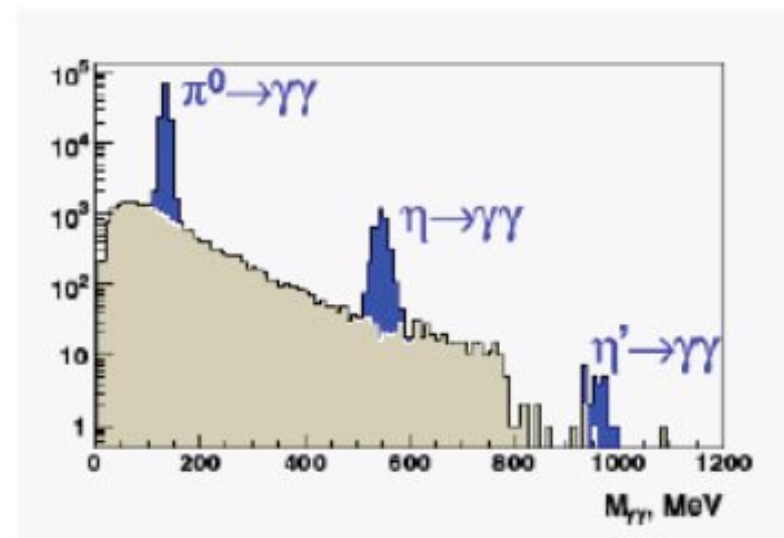
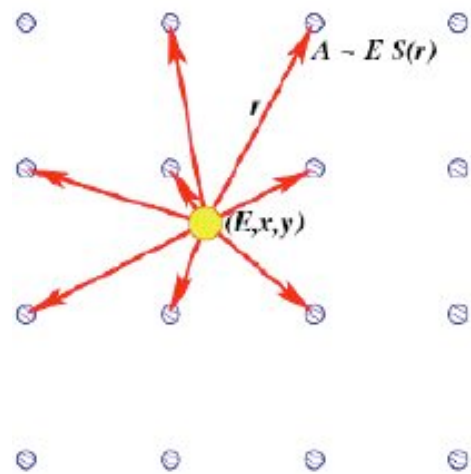
Tunnel 1-2



Tunnel 8-1



IP1



Large channel count “EM” style module only one side. Cost issue.

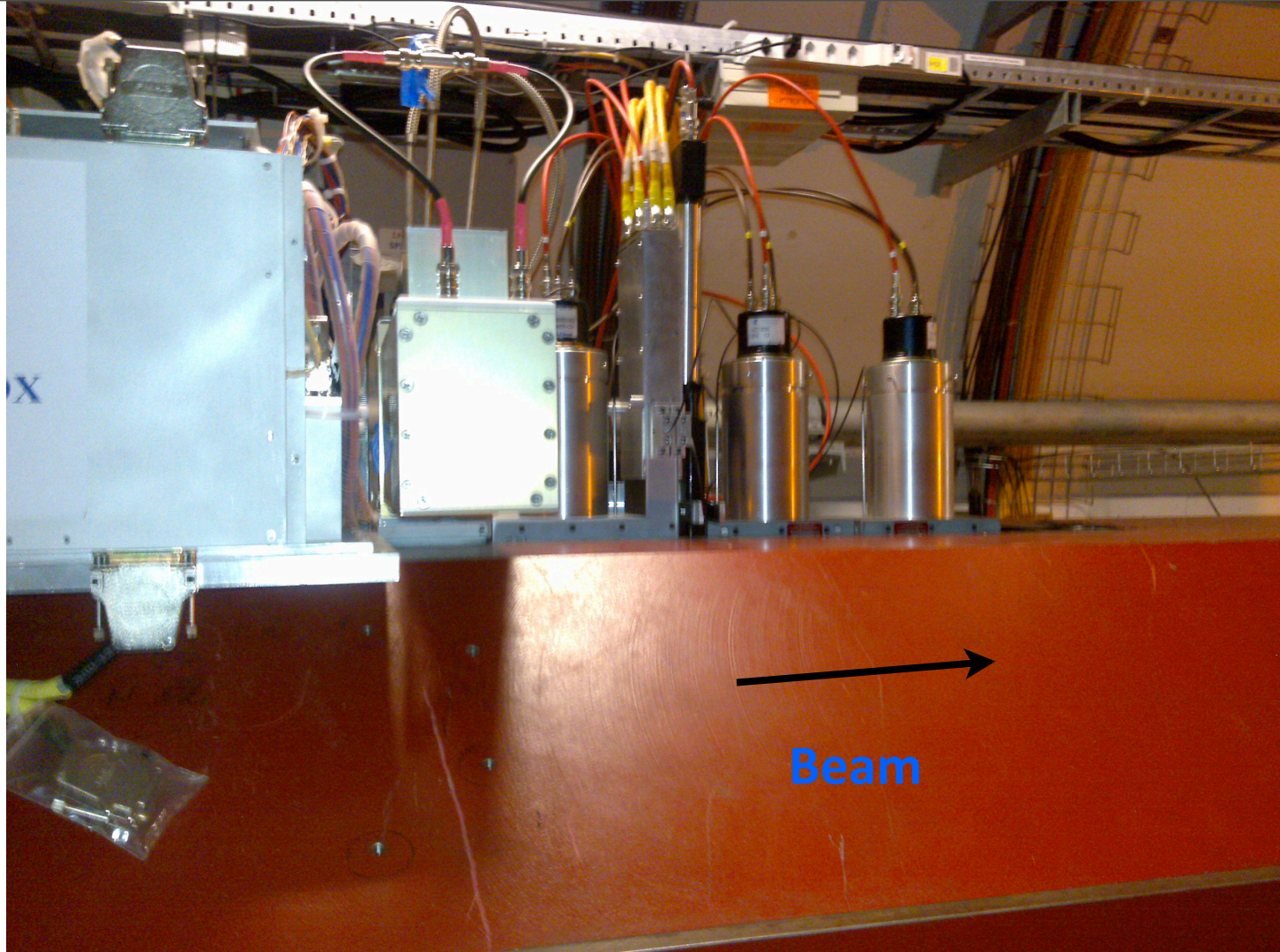
We have worked to realize full EM functionality in spite of funding setbacks

Only ~\$25k PPM is missing.

Coordinate readout is critical for event geometry in HI. Algorithm based on a very strong position dependence of energy/fiber.

Open side showing x,y quartz rods.  
Energy measuring strips already in place.

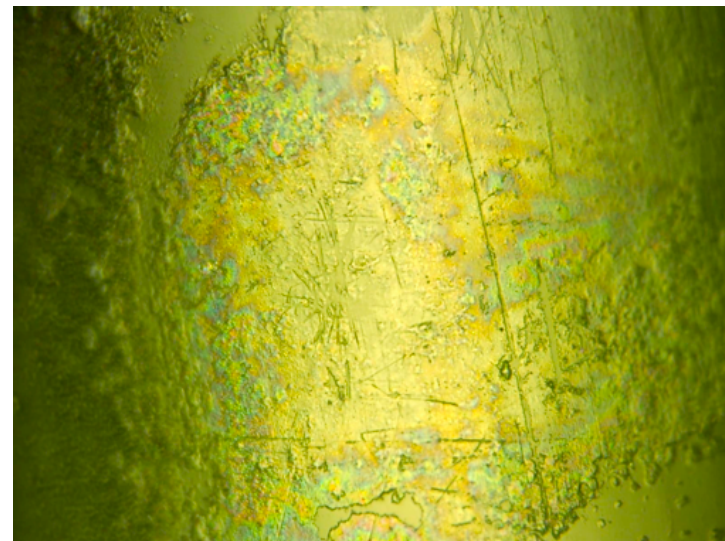
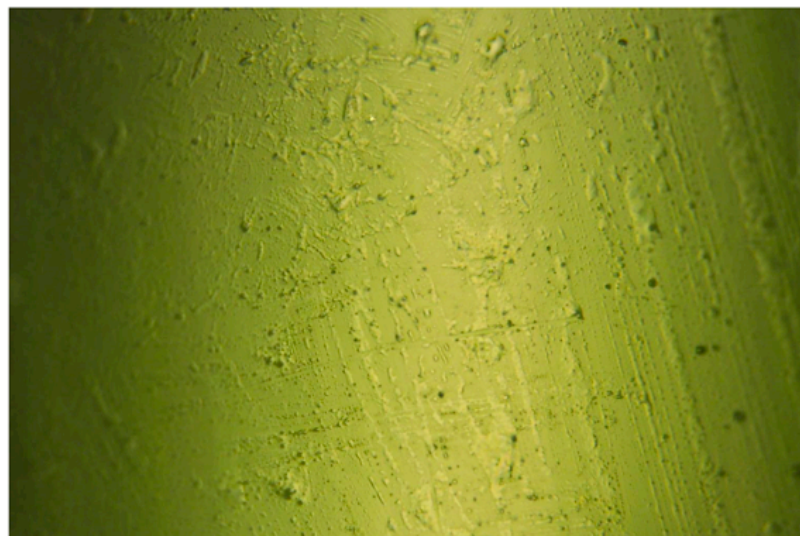




Current TAN geometry:

LHCf, BRAN, ZDC(x,y), Sci, 2\*ZDC

ATLAS formally requested (F. Gianotti, M. Nessi, S. White) that LHCf be removed in ~Feb. and replace with ZDC-EMCal



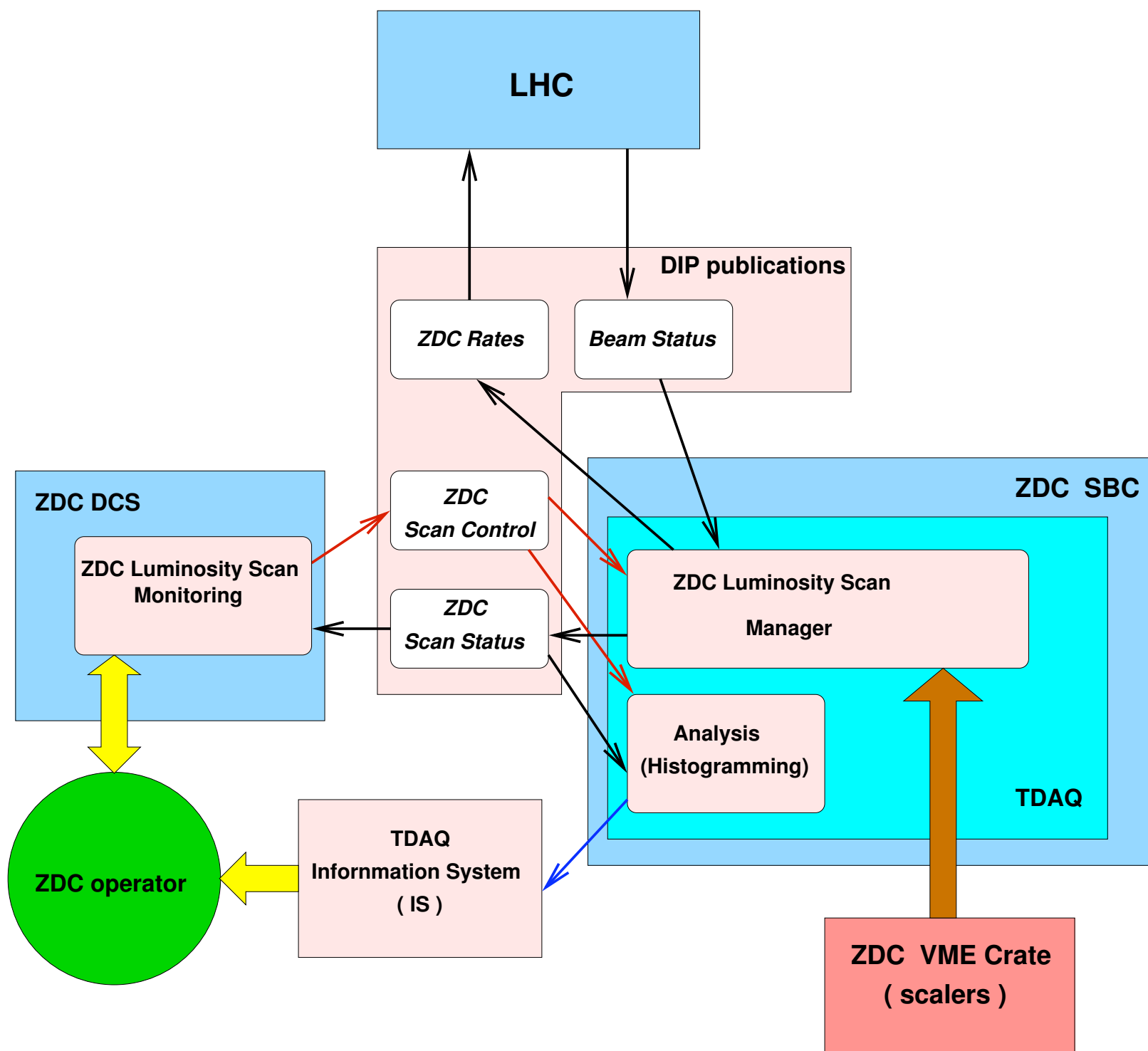
Pre and Post-irradiation micrographs of fused silica  
(N. Mokhov, N. Simos, G. A., S.N.W. IEEE and PAC papers)



# ZDC Luminosity Scan Configuration

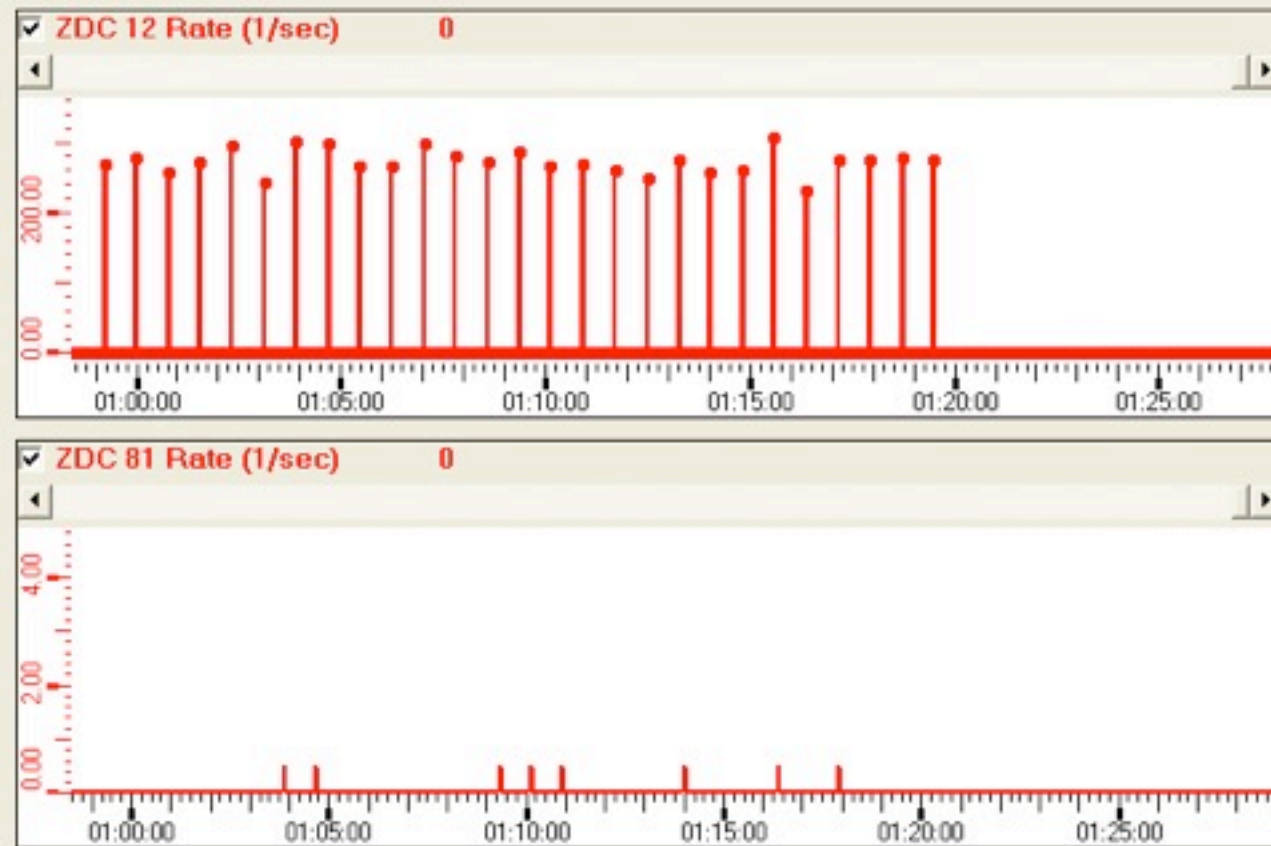
requires communication over several protocols, including LHC accelerator ones

Commissioned by Andrei in Thanksgiving '08 holiday

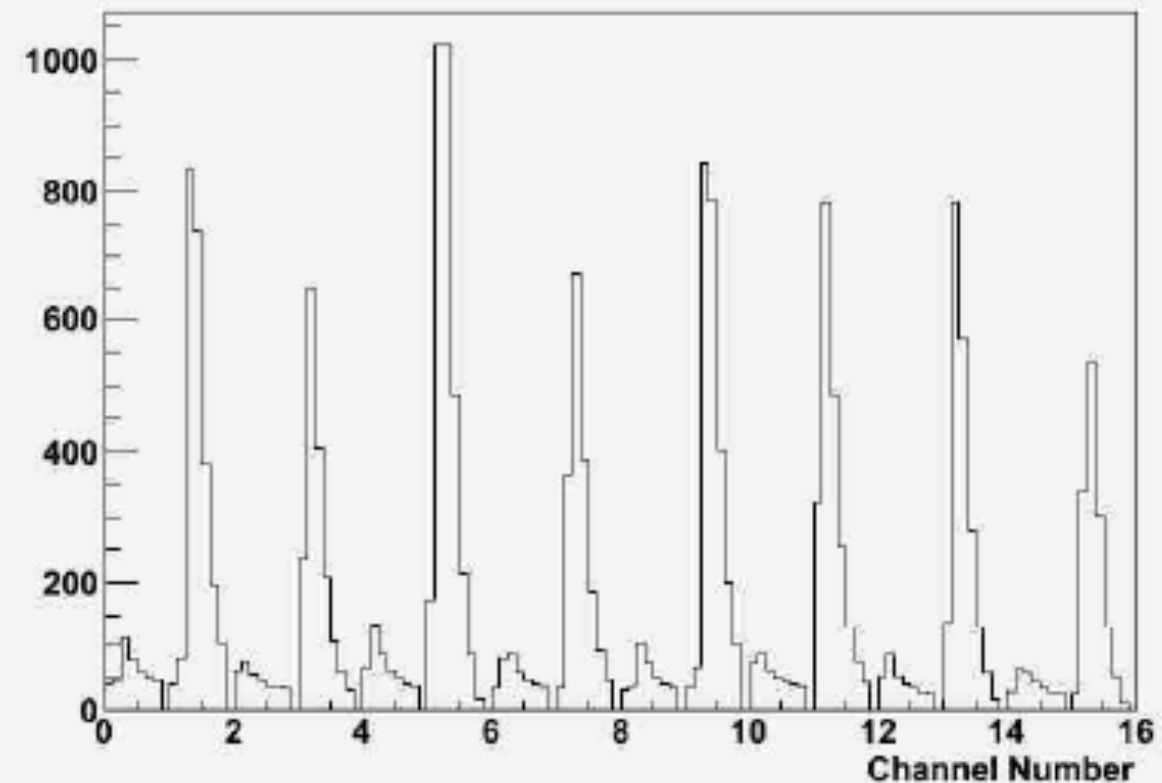


## ZDC Scalers

Integration time 2.0



**Beam Splash Events in ZDC Scalers**



**LED pulses in Heidelberg-made Pre-processor module running in 7-slice configuration. We purchased the PPMs in July '09.**

**The ZDC project plans to buy 2 more PPMs that were in original project. This would complete DAQ for EM pixels also.**

# Cost Rollup

From: Sebastian White  
Subject: **ZDC outlook**  
Date: August 21, 2009 8:34:56 PM EDT  
To: Robert E Ernst  
Cc: Sebastian White , E. O'Brien <eobrien@bnl.gov>  
▶  2 Attachments, 483 KB [Save](#) [Quick Look](#)

Dear Bob and Ed,  
I feel I owe you some kind of summary on ZDC status and costs.

## 1) Status

- 3/4 ZDC modules (hadronic ones) are installed on each side
- 2 EM modules require minor work to complete (below). ATLAS wants them in ~January when LHCf removed.
- full trigger/daq in place and tested for all modules. Many processes integrated and stress tested by ATLAS.
- we will need to buy 2 PPMs (total=\$25k) to also read out EM pixels on one side. Beyond BNL project cost.

## 2) Funding sources.

-BNL: Our understanding last spring was that of a total expected funding of \$343k, up to \$323k was committed through FY09. The major cost item was payment to Heidelberg for 2 PPMs (total \$25k). In July I submitted a TID for this amount at CERN. We have exceeded the FY09 amount by several k\$ due to BNL electronics, central shop charges and a shipment to CERN which we should discuss.

-Yale: The University directly contributed at a critical point with \$50k to the project. Mike Zeller's current request to DOE includes the \$25k to buy the PPMs needed for the EM pixels. We don't know the outcome.

-Columbia: Brian Cole received \$40k from the University which was used to buy a ROD card for the readout (12 k £/2).

Brian is planning on spending additional money on things that enhance ZDC performance for other ATLAS roles, such as luminosity monitoring- for example, faster waveform digitizers and additional workstations.

-Other Institution:- the ZDC has active participation also from NYU, Sao Paulo, Valparaiso and Dubna. All, in principle, could contribute on future equipment.

## 3) Cost to Complete:

This means installation and commissioning of also the 2 EM modules (assumed to be ~Jan-Feb-2010).

The assembled modules are now at BNL but one needs work. We require:

800\$ in material	
1.5 wk mechanical tech	(assumed no cost)
2.5 wk electrical tech	(assumed no cost)
2 piece welding at central shop	(~250\$ ?)
Shipping cost to CERN	\$500



#### 4) Issues about Project completion

- the 2 remaining PPMs would be a big asset but we are delivering the basic performance- particularly for Heavy Ions- without them.
- the LHC has required of us shielding items for radio-protection ( to limit the dose to riggers handling the ZDC). The total costs are

4 Sarcophagi @\$5k

Shielding blocks total = \$7k

There have been attempts to get CERN or ATLAS to pay these costs but there's no solution yet. We haven't heard about the blocks lately but Kansas would like payment for at least half of the sarcophagi soon.

- some of our equipment is on loan or rented from the CERN electronics pool. It would be nice to eliminate the rental cost (70 CHF/month). The 1 cm PMTs we got from E787 and will eventually need to return to the KEK owners. For new replacements this would cost \$60k.

- there are improvements which should be made to the signal processing of the BNL made FEE's.

#### 5) ATLAS rollup

- the technical coordinator has requested a summary of activities for all systems through the next 4-5 years. Below is a first stab at the ZDC part, which we'll iterate over the next month. In it are included the above issues.

### *Lucid, Alpha,ZDC*

item	Description/justification	cost estimation (KCH,	funding (M&O A/B/C, new M&O, new funds, FDL, not defined	date start
replace 1cm PMT's	120 now on loan from KEK	60	new funds	Jun-10
shielding	deferred cost for radioprotection	7		
2 sarcophagi	deferred cost for ZDC storage at high luminosity	10	new funds	Jun-10
purchase loaned electronics	currently NIM crates, modules,HV rented from CERN pool	8	new funds	Jun-10
2 PPMs for EM module	EM module readout is beyond current scope	25	new funds	Jun-10
high rate FEE	current pulse shape causes pileup at L=10 <sup>31</sup> -10 <sup>32</sup>	8	new funds	Jun-10
oscilloscope	for maintenance	12	new funds	Jun-10
	total	130		



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ZDC/BNL construction closeout

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# 9/09 with Ed and Bob(2)

ZDC Financial Data					
Sep 09 - Preliminary Closing Data					
Account 50044					

## Tasks to complete remaining ZDC modules

### EMM 1 (=standard HM)HM

- **Mechanical part:**
  1. Lifting fixture (1) (BNL). done
- **Cables: (BNL?)**
  1. Signal coaxial 5m (2+2); 4(BNC-BNC) 12\*2\*7=168 USD total
  2. HV 5m (1+1); 2(SHV-SHV)
  3. HV 1m (1+1). 1(SHV-SHV)

### EMM 2

- **Mechanical part:**
  1. Modification of EMM (holes and gaps for monitoring holder) (BNL); done
  2. Lifting fixture (1) (BNL); done
  3. Small PMT-s Holders: Yale
    - Holder for 8 PMT-s (8)(Yale?);
    - Box for small PMT-s (1)(Yale?).
  4. Bend the 1.2mm quartz rods (100) (Yale -done);
  5. Holder for bent rods (1) (Yale-done);
  6. Monitoring system:
    - LED\_PIN Diode box (1); NYU
    - Optic cable (8+8); (NYU?) NYU-done
    - Holder of optic cable (8+8) (BNL-done)
    - Holder for monitoring quartz fibers (8) (Yale /BNL- done).
  7. Bottom Spacer (1) (Yale - done);
  8. Safety Cover for edge of bent rods (1) (BNL- not done?).
- **Electronic part:**
  1. NIM module of HV adapter (2); 400 USD
  2. Bases for small PMTs. (BNL-Physics??)
- **Cables: (BNL has twisted pair, but must cut)**
  3. HV 5m (2); 2(SHV-SHV) 48 USD
  4. HV 1m (8+1+1); 10(SHV-SHV) 240 USD
  5. Signal 4-twisted pair 5m (16); 16(Dsub-Dsub) 32\*5=160 USD
  6. Signal 16-twisted pair 1m (8+1); 9(Dsub-Dsub) 18\*5= 90 USD
  2. Signal coaxial 5m (4); 4(BNC-BNC) 12\*2\*7= 168 USD
  7. 9 pin D-sub 0.5m (1). 1(Dsub-Dsub) 10 USD
- **Other parts**
  1. Socket for small PMTs 64+2; 66\*15=990 USD
  2. Quartz optic fiber – 40m (BNL) (NYU Bought);

**Note: cost of cable (halogen free) material and assembly not included.**

**Note: NYU has committed to buy above remaining materials(\$2,274).**

All

It is my understanding that there is a requirement of assembly for some number of PMT tube base PCB's in order to complete the balance of additional channels for ZDC.

Pierrot has worked on these assemblies in the past and is an excellent candidate to complete this task. John Hammond designed the PCB and has the necessary assembly drawings to provide for Pierrot. The spare blank PCB's, as well as the critical components had been given to Grigor Atoian.

I ask that Pierrot proceed by seeing John Hammond for documentation, as well as Grigor for the blank boards and components, in order to begin the assembly work.

I also suggest that Pierrot contact Sebastian White and coordinate with him, the time table for deliverables. Feel free to contact me with questions or concerns.

Thanks

Dan Padrazo

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Sebastian,

I went to talk to Ed O'Brien about this, since I wanted to get a better understanding of what the status of the project is, and how well it will be supported in general.

It seems that the ZDC EM is not quite in the approved scope of the ZDC. So maybe it will be useful to get together with Ed on this, to see which parts of the ZDC EM is already covered, and which parts are not. As much as we want to help you with the work on ZDC, I want to make sure we don't get into trouble on this.

Hong.

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ZDC/BNL construction closeout

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# Bigger Loose ends

*Lucid, Alpha, ZDC*

Summary I gave to  
Marzio, Ed & Bob  
Sept. 09

item	Description/justification	cost estimation (KCH,	funding (M&O A/B/C, new M&O, new funds, FDL, not defined	date start
replace 1cm PMT's	120 now on loan from KEK	60	new funds	Jun-10
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high rate FEE	current pulse shape causes pileup at $L=10^{31}-10^{32}$	8	new funds	Jun-10
oscilloscope	for maintenance	12	new funds	Jun-10
	total	130		

## ZDC Institution Plans

### NYU (current year)

40 hours of a design engineer@\$64/hr=\$2,560,  
100 hours for a machinist@\$25/hr=\$2,500  
an additional \$1,200 for materials.

### Universidade de S\~ao Paulo (current grant application)

- the group has contributed \$425K to PHENIX
- lessons learned will be used for ATLAS (ie should any funding go through BNL?)
- planning to participate in several hardware parts: WFD hardware, purchase PPMs, purchase a part of loaned CERN eqpt., possibly 2nd EM module
- not interested in Sarcophogi
- very likely that total resources equal to those spent on PHENIX
- they have also understood their operating costs

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- currently funded from several grant sources
- expect to fund ZDC hardware enhancements @ several 10's k\$/year
- committed to seeking additional funding
- 4 students \* 3 weeks a year at CERN
- very strong pool of Masters students also
- the group, due to close ties to Levin, Kopeliovich, etc. plans to take a very active role in forward physics with the ZDC

Columbia, Dubna, Yale, SUNY

ongoing discussions.

BNL operating (proposed)

CERN travel

CERN equipment rental (80\$/month- BNL, 300\$/month- Yale)

CERN team account @ \$1k/year

Space charges for joint ATLAS/RHIC ZDC lab at BNL

# hyperlinks

take

**From:** Michael Murray  
**Subject:** ZDC luminosity  
**Date:** October 16, 2009 6:06:24 PM EDT  
**To:** Sebastian White

Dear Sebastian,  
how will you use the ATLAS ZDC for luminosity.  
Michael

**From:** Michael Murray <mjmurray@ku.edu>  
**Date:** August 4, 2009 12:05:06 PM EDT  
**To:** Sebastian White <swhite@bnl.gov>  
**Subject:** Event Generators

Dear Sebastian,  
do you have any recommendations for event  
generators for leading neutrons in pp.  
Michael  
+1 785 550 8835

and give

**From:** Michael Murray <mjmurray@ku.edu>  
**Date:** July 24, 2009 4:58:09 PM EDT  
**To:** <xavier.rouby@cern.ch>  
**Cc:** Sebastian White <swhite@bnl.gov>  
**Subject:** Re: Hector/ZDC

Dear Xavier,  
Sebastian White has built ZDCs for ATLAS. He would like to talk to you  
about using HECTOR to get them into the full simulation.

Michael

Link-back

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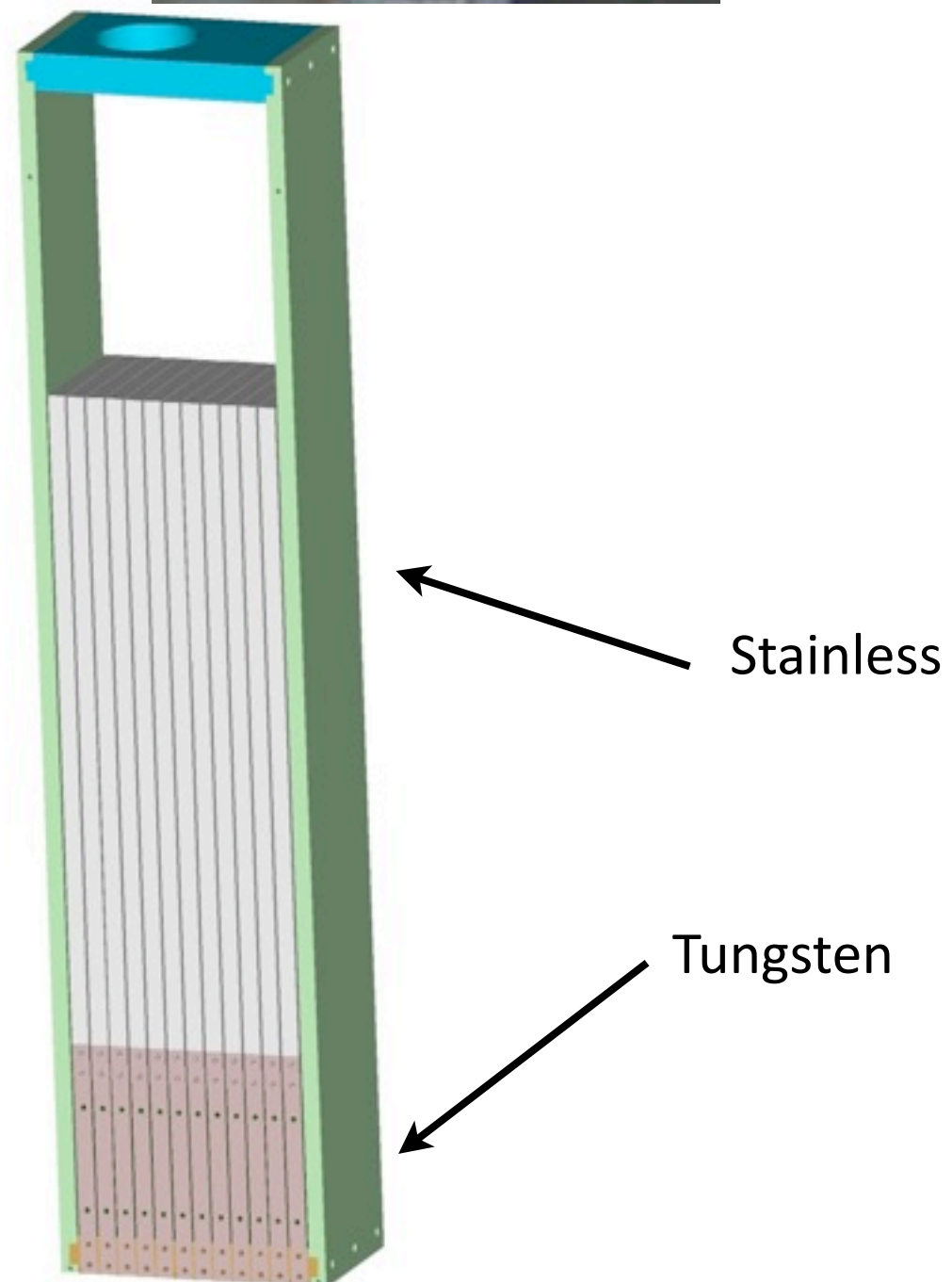
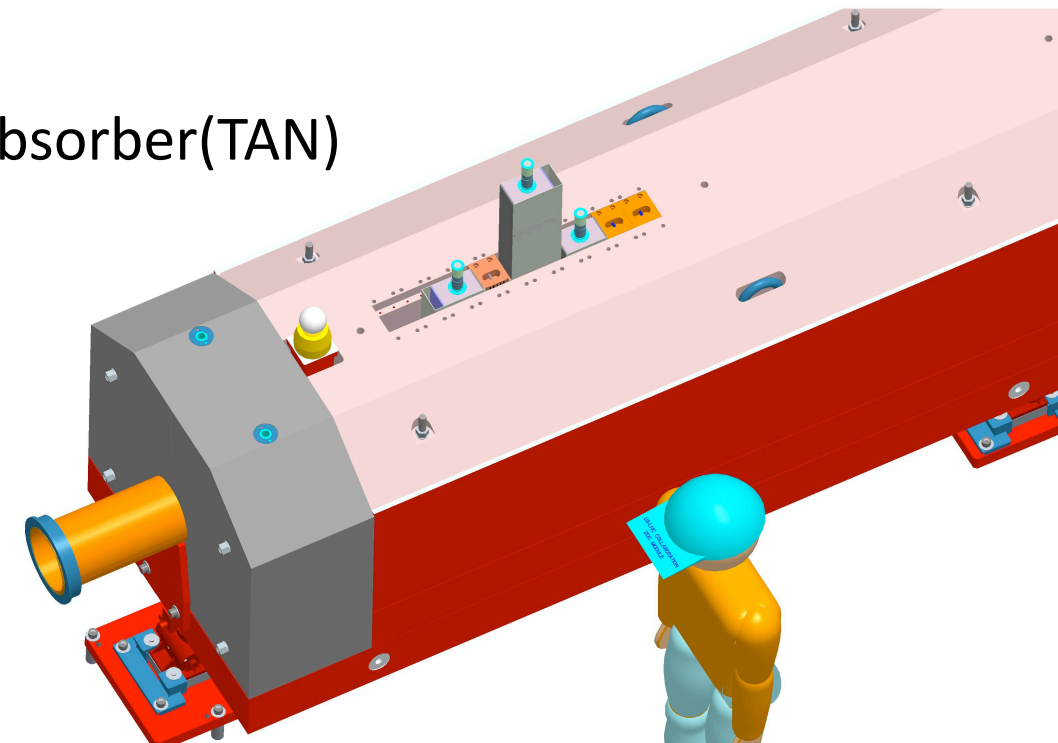
# Alexei on PHENIX/ATLAS

Pb/Scintillator EMCAL (PHENIX)	March '93->present	All project files,design, fab,testing, Pb/Sc operation
RHIC ZDCs	June '99-> present	Design, simulation + fab (of PHENIX and Brahms)
PHENIX normalization/ trigger counters	5/01-5/02	Design and fabrication
PHENIX shower maximum detector	5/02-> Present	Design, Simulation, Fab
RHIC Luminosity calibration for Au-Au	Aug '01	data analysis
RHIC Luminosity Calibration for d-Au	Nov. '05	data analysis, calibration of PCAL
ATLAS ZDC	9/02->1/06	Initial design and simulation 3-d model, integration



# Denisov design

Neutral Absorber(TAN)



Design based on Quartz clad/  
Quartz core 0.3 mm  
optical fibre (Polymicro)